Areawide Pest Management

An Effective Strategy for Many Pests

SANFORD PORTER (K8575-24)

A fire ant decapitated by an enzyme released from a mature phorid fly larva living inside the host ant.

In 1994, the Agricultural Research Service launched an ongoing series of areawide integrated pest management (IPM) projects. Each project was proposed from the field and reviewed by a technical staff. Although each project has research, education, and assessment components, the focus has been to pull together existing technology and research results into an integrated management plan that could be demonstrated for, and transferred to, users. Each project is funded for up to 5 years and then carried on by cooperators, growers, and land owners.

So far, the projects have met or exceeded their goals. All have shown significant reduction in pesticide use and have garnered wide support, ranging from scientific colleagues to individual farmers. This article profiles six areawide IPM projects for fire ants, fruit flies, stored-grain insects, leafy spurge, corn rootworm, and codling moth.

Additional areawide programs were funded in 2001 to tackle lygus bug, Russian wheat and green peach aphids, and melaleuca trees.

Even though the individual projects are time-limited, their success shines through as users continue them without the official infrastructure initially provided by the projects.

One of the most recent ARS-funded areawide projects, which began this May, is part of a long-fought campaign to control the red imported fire ant, *Solenopsis invicta*.

The Areawide Suppression of Fire Ant Populations in Pastures is a partnership among ARS, the USDA's Animal and Plant Health Inspection Service, the University of Florida, and Texas A&M and Oklahoma State universities.

The goal of the project is to demonstrate how to reduce fire ant populations to very low levels by combining strategic pesticide applications with two self-sustaining biocontrol agents from South America: the fire ant-decapitating fly, *Pseudacteon tricuspis*, and the pathogen *Thelohania solenopsae*. As scientists introduce these agents, fewer subsequent bait toxicant treatments should be needed to maintain fire ant control, according to Richard Brenner. He is the former head of ARS' Imported Fire Ant and Household Insects Research Unit at the Center for Medical, Agricultural, and Veterinary Entomology in Gainesville, Florida.

Diverse demonstration sites as large as 640 acres in the three states were chosen to represent the range of the fire ant's infestation, according to Brenner. ARS will direct the major activities of the three land-grant universities and other organizations associated with the project for 5 years. ARS will also add a site in Mississippi in 2002.

The fire ant has swept onto the American landscape with an ever-increasing impact. It now infests more than 318 million acres in 12 southeastern states and Puerto Rico. Recently, populations have also become established in California and New Mexico.

"The project should result in reduced livestock and equipment losses from fire ants, increased farm worker safety, and reduced pesticide risk," Brenner says.—By **Jim Core,** ARS.

This research is part of Arthropod Pests of Animals and Humans, an ARS National Program (#104) described on the World Wide Web at http://www.nps.ars.usda.gov.

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Forcing Exotic, Invasive Insects Into Retreat: New IPM Program Targets Hawaii's Fruit Flies

In Hawaii's warm, mild climate, exotic tropical fruits and vegetables, as well as more familiar fare, flourish nearly year-round. Unfortunately, so does a quartet of subtropical fruit fly pests—the Oriental fruit fly, melon fly, Mediterranean fruit fly, and solanaceous (Malaysian) fruit fly.

These invasive insects, none native to the Hawaiian Islands, can easily turn what should be a fresh, luscious taste treat into a disgusting mess. That's what happens soon after the female fruit fly punctures the skin of a nicely ripening fruit or vegetable and pumps her eggs into it. The tiny, wriggling maggots that later hatch spoil what would otherwise be a delectable crop.

ARS researchers are targeting these troublesome flies in one of the agency's newest and most complex areawide integrated pest management (IPM) programs. The goal: to give Hawaii's growers the latest and best science-based, environmentally sound strategies for reducing crop losses and the need for organophosphate and carbamate insecticides.

Gearing Up Grid by Grid

"Our intent," says ARS entomologist Eric B. Jang, "is to help farmers keep the flies under control in carefully delineated suppression grids." These grids might include not only participating growers' fields and orchards, but also nearby vegetation where significant numbers of exotic flies live and breed. Groves of wild guava in pastures that are within a few miles of a melon field or nearby backyard plantings of pumpkin or zucchini, for example, might need to be included within a grid. If not, the insects could use the grove or garden as a safe haven and as the base for their attack on the neighboring fields.

Jang leads the ARS Areawide Pest Management Program on Fruit Flies in Hawaii. He is based at the agency's U.S. Pacific Basin Agricultural Research Center in Hilo.

"The program involves a combination of tactics we think will be practical, affordable, and workable, not just one method for going after flies in these suppression grids," Jang says. The grid approach is "very different from attempting to obliterate the fruit flies everywhere they live in the Hawaiian Islands chain.

"Our program is unlike many of the other areawide IPMs," notes Jang. "We're targeting four key pests, not just one. We have dozens of crops at risk from these flies: papaya, mango, melon, squash, cucumber, tomato, pepper, and eggplant, not just a single commodity like corn."

SCOTT BAUER (K9580-2)

Grower Betsy Sakada shows ARS entomologist Eric Jang fruit fly damage on her peach trees.

Partnering with State and University Scientists

Interest in the program is growing among farmers in the Aloha State, including some who were initially reluctant to join the project. Today, plans call for using at least four different control tactics—sanitation, male annihilation, bait sprays, and biological controls—at demonstration sites on the islands of Hawaii, Maui, and Oahu.

The program is a joint venture of ARS, the University of Hawaii, and the State of Hawaii Department of Agriculture. Scientists and specialists from these institutions are dividing up the work of developing and demonstrating technologies for suppressing the voracious fruit flies. Other partners include grower organizations and agricultural businesses.

Thorough and unrelenting sanitation that removes as much infested fruit as possible is basic for every orchard and field. These culls may, for example, get tossed into bins, barrels, plastic bags, or pits. Another tactic some local growers use—drowning ruined fruit—is being scrutinized.

A procedure aptly named "male annihilation" is a proven success at zapping fruit fly males. That causes populations to collapse. Male annihilation relies on traps that contain an irresistible lure to bring the flies to it and a second compound that kills them once they touch or eat it. ARS scientists at the Hawaii laboratory have played a key role in developing powerful lures that entice Oriental fruit flies, melon flies, or medflies to visit these deadly traps.

Bait Sprays and Biological Controls

Protein-bait sprays applied from the ground provide another way to blast the flies. Key to these sprays is protein derived from corn, wheat, or other sources, which the flies find too good to resist. When mixed with a compound that kills the flies, such as spinosad, growers have an effective and environmentally safe weapon in their toolkit. In outdoor tests, conducted over the past several years in Hawaii, ARS research entomologist Roger I. Vargas and colleagues

SCOTT BAUER (K9579-1)

Areawide site coordinator Mike Klungness services bait traps placed in this tentlike structure called an augmentorium. He'll collect the flies that come out of infested fruit inside the tent. The beneficial parasitoids that emerge from the fruit fly pupae can escape through the yellow screen at the top of the tent.

have provided some of the best available information about the effectiveness of spinosad against tropical fruit flies.

A biological control tactic known as the sterile-insect technique offers yet another way to outwit the flies. It requires releasing flies that have been sexually sterilized in the laboratory. When these sterile males mate with wild, fertile females, no fertile offspring result, so the population dies out.

Key to this technology is the ability to continuously rear populations of healthy flies that can outcompete wild, fertile males in winning the attention of the females. In past decades, ARS scientists in Hawaii have developed, tested, and fine-tuned all the steps needed to raise laboratory colonies of the invasive fruit flies—a must for the sterile-insect technique.

The researchers have also refined the process of rearing masses of a hard-working biological control agent named *Fopius arisanus*. This tiny wasp is harmless to humans. Female wasps parasitize fruit flies by inserting their eggs into fruit fly eggs. Puncturing the eggs kills some fruit fly young outright. Others die when parasite young develop inside them.

SCOTT BAUER (K9589-1)

SCOTT BAUER (K9577-1)

Psyttalia fletcheri **(above) is the only fruit fly parasitoid introduced into Hawaii capable of parasitizing the melon fly (right)** ***(Bactrocera cucurbitae).***

New Findings Wait in the Wings

New discoveries by ARS scientists should streamline use of the sterile males and busy wasps. Geneticist Donald O. McInnis, based at the center's Honolulu laboratory, has bred a line of melon flies that can be mechanically sorted according to their sex while they are pupae—the last stage before they become adults. In the wild, both males and

SCOTT BAUER (K9587-2)

Student intern Donna Ota examines papaya for larvae that may not have pupated yet. The bucket next to her is used to rear larvae to the pupal stage.

SCOTT BAUER (K9585-3)

Fruit fly larvae in papaya.

females normally have a brown pupal case, a cocoonlike covering. In McInnis' line, in contrast, only males have this brown casing. The females have a telltale white pupal case. High-speed color-sorting machines are used to segregate the genders, according to McInnis.

White-encased females are thrown away, while the males are put aside for the outdoor work. Simple, fast, and reliable, this color-sorting strategy saves some of the time and expense that would otherwise be invested in unneeded females. Though similar breeding work has been done elsewhere to produce color-sorted strains of other fruit flies, McInnis' work is a first for the melon fly.

Also in the wings is a new and more efficient way to raise the tiny *F. arisanus* wasp indoors. Entomologists Renato C. Bautista and Ernest J. Harris developed a new breeding cage that streamlines the rearing procedure, offers savings in labor, and enables laboratory managers to produce a steady supply of the hard-working wasps for lab and field tests. What's more, the scientists are testing the same cage for possible use as an outdoor delivery system for another beneficial insect, *Psyttalia fletcheri*. This diminutive wasp is a powerful natural enemy of the melon fly. The delivery system could, Bautista says, provide researchers and growers with a quicker and easier way to distribute the wasps throughout their fields and orchards. Bautista and Harris plan to seek a patent for their invention.—By **Marcia Wood,** ARS.

This research is part of Crop Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at http://www.nps.ars.usda.gov.

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Spreading Good Management Practices Among Grain Elevator Managers

PEGGY GREB (K8805-10)

Entomologist Paul Flinn looks at the Stored Grain Advisor, a program that predicts how long grain can be safely stored, provides advice to grain managers, and identifies insect pests.

Remember that old saying about how important it is to make new friends but keep the old, for one is silver and the other gold? That's how ARS researchers in Manhattan, Kansas, feel about the relationships they've built with grain elevator managers during a 4-year areawide integrated pest management (IPM) project, which began in 1997, in Kansas and Oklahoma.

"We've recently added some new elevator managers into the network while still keeping relationships with managers who were involved in the study from the beginning," says ARS entomologist Paul W. Flinn at the Grain Marketing and Production Research Center in Manhattan. Flinn and retired ARS entomologist David W. Hagstrum, along with researchers from Kansas State and Oklahoma State Universities, worked as a team to develop relationships with grain elevator managers, who provided important feedback during the project.

"In the last phase of our work, we found that sampling for insects with a vacuum probe in the top 40 feet of grain helped detect insect infestations and saved time and labor," says Flinn. He also put the finishing touches on a risk analysis database, designed to determine whether treatment is needed. The database and the vacuum probe should help managers save time and money by avoiding unnecessary fumigation in silos, says Flinn. Another plus: the risk analysis database helps managers determine the condition of carryover grain in silos before the new harvest.

The database analyzes insect density, grain moisture, and grain temperature for all the silos at an elevator. The information is provided to the manager in the form of a silo diagram: Silos in red are at risk and should be fumigated, while silos represented in green are safe. The software uses a computer model to forecast insect densities in the silos for up to 3 months.

That feature reduces the need for frequent sampling, keeping costs low. The program generates a one-page summary of information and specific recommendations, which may include cooling the grain to reduce insect densities or, if needed, selling the grain sooner.

"After we talk to the managers about their options, we return in 60 days to evaluate what they've done," says Flinn.

Fumigation of an entire elevator that stores 700,000 bushels of wheat could cost about $14,000. But, if only three bins have high insect densities, the cost of fumigation for those three bins may be only $1,400. That's a savings of $12,600.

A cost-effective alternative to fumigation is to cool wheat soon after it's placed into storage in late June or early July by using fans that turn on when outside air temperatures are 10 degrees less than the grain temperature.

By providing alternative strategies for pest management, this research—and the support of ARS, Kansas State University, and Oklahoma State University scientists—has resulted in less reliance on phosphine, a widely used pesticide for insects in raw grain.—By **Linda McGraw,** formerly with ARS.

This research is part of Crop Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at http://www.nps.ars.usda.gov.

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TEAM Leafy Spurge Links Technology and People To Manage Weed

Cows and horses won't eat it, native grasses can't compete with it, and landowners across at least 36 states and Canadian provinces have lost land to it: the noxious weed leafy spurge.

Leafy spurge first appeared in the United States in 1827 and has doubled its coverage every decade for a century. To help stem its spread, ARS established The Ecological Areawide Management (TEAM) of Leafy Spurge in 1997.

"The goals of this program were to increase public awareness of the weed and pull together research results in a way that helped ranchers and land managers choose the best options for their situation," says ARS ecologist and TEAM Leafy Spurge program manager Chad W. Prosser.

TEAM Leafy Spurge, which officially ended this year, was ARS' first areawide program to address a weed. Co-managed by USDA's Animal and Plant Health Inspection Service, the program brought together a diverse collection of cooperators, including numerous federal agencies, land-grant universities, state departments of agriculture, cooperative extension services, and ranchers and landowners from across the region.

"'TEAM' is more than a cute acronym," says ARS ecologist Gerry L. Anderson, co-principal investigator of the program. "Our key role and greatest accomplishment has been establishing partnerships that will last well beyond the length of the official program." Both Prosser and Anderson work at ARS' Northern Plains Agricultural Research Laboratory in Sidney, Montana.

To accomplish their goals, TEAM set up a demonstration area covering 4 states along the 300-mile Little Missouri drainage basin. The study sites included a wide range of habitats, from open plains to crucial riparian areas, so that management strategies could be demonstrated in the kinds of real-life situations ranchers face.

At nine field events, scientists demonstrated the effectiveness of various combinations of biological control agents, sheep grazing, and herbicide applications. Landowners lined up by the hundreds to collect millions of flea beetles that feed on the weed.

"We distributed more than 47 million beetles for biological control during the program," says Anderson. TEAM Leafy Spurge also produced several informational products, including a biocontrol manual that has been distributed to more than 33,000 users in 16 states and Canadian provinces, an updated version of the award-winning Purge Spurge CD-ROM database, and a biocontrol CD. More products are being developed.

On the scientific front, TEAM Leafy Spurge scientists showed the efficacy of biological control and clarified the ecological needs of existing control agents, and they continue to test additional agents for future release.

They also pioneered remote sensing as a viable tool for monitoring the existence and spread of a rangeland weed. Specific sites covering several hundred acres illustrated combinations of biological control, multispecies grazing, and herbicide application to keep spurge at economically manageable levels.

"All the pieces of the puzzle are coming together," says Prosser. "There's no doubt in my mind that spurge will be an incidental plant when integrated management plans are carried out over large areas using these tools."—By **Kathryn Barry Stelljes,** formerly with ARS.

This project is part of Crop Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at http://www.nps.ars.usda.gov.

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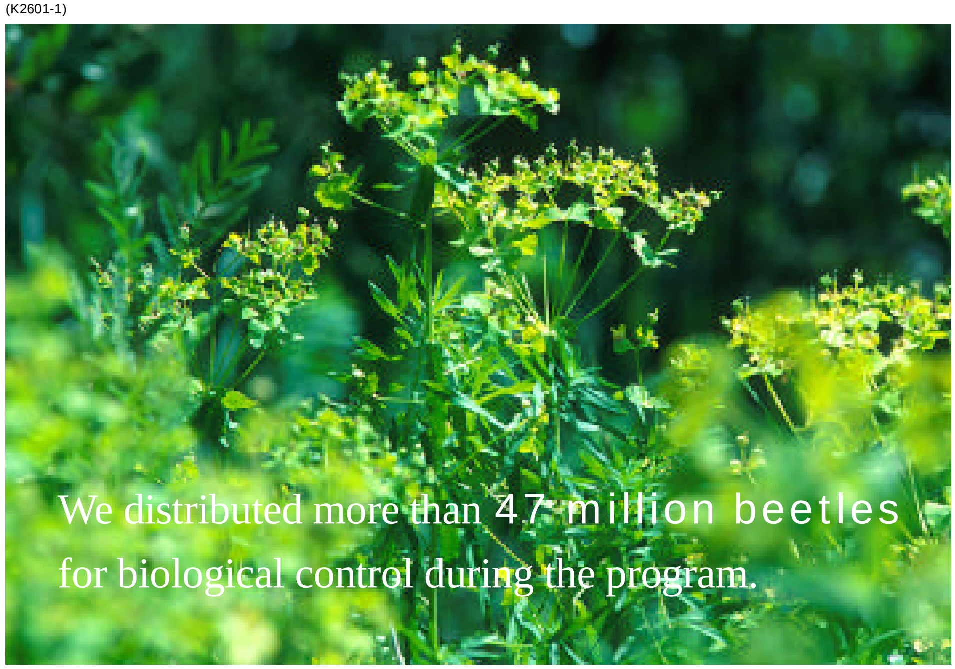

Leafy spurge.

Bait-and-Kill Strategy Can Slash Insecticide Use in Corn Belt

Field tests in the Corn Belt have proven that "aerial spraying with a bait slurry can drastically reduce the amount of insecticide active ingredient used," says ARS entomologist Laurence D. Chandler.

Chandler is describing a successful conclusion to the corn rootworm areawide integrated pest management (IPM) project. "It's in its last year, and next year we will complete the handover to IPM consultants who will help farmers adopt practices we developed in conjunction with university scientists," Chandler says. He's at the ARS Red River Valley Agricultural Research Center, Fargo, North Dakota.

Chandler says the bait testing began with the 1997 corn crop and was part of one of the first areawide projects to target pests of a row crop. Chandler is program coordinator for the project.

"During the program, we tested two new, low-insecticide baits that use either a watermelon juice ingredient or wild buffalo gourd root powder because both contain cucurbitacins that act as feeding stimulants to adult rootworm beetles. We also evaluated a trap that uses corn rootworm attractants derived from plant-produced chemicals," Chandler says.

"All these products came from technology that ARS helped develop and became commercially available during the areawide program. The product evaluations were done at four 16-square-mile sites across the Corn Belt—at the Indiana-Illinois border and in Iowa, Kansas, and South Dakota—and at smaller study sites in Texas."

The baits use doses of insecticide at rates of an ounce or less per acre—95 to 98 percent less active ingredient than in conventional sprays. They are sprayed aerially on corn leaves where the beetles eat. The bait lands on leaves and forms individual drops containing cucurbitacins and insecticide. The cucurbitacins cause the beetles to feed preferentially on the drops and ingest a lethal dose of insecticide.

Entomologists Larry Chandler (left) and Wayne Buhler check a corn ear for corn rootworm damage.

"If used throughout the Corn Belt, the bait sprays could reduce total pesticide use on corn by half," Chandler says.

Corn rootworms are the target of almost half the insecticides used in row crops in this country, requiring more insecticide than any other pest. "About 25 million acres of corn are treated each year," Chandler says. "In some years, rootworms can cost farmers up to $1 billion in crop losses and spraying expenses."

The baits are sprayed only when IPM scouts or farmers find an average of one female beetle per plant or when populations in various traps exceed a certain threshold. That is the level at which they can begin to cause significant economic harm to a farmer, enough to justify the expense of spraying.

Chandler explains that it is the beetle's offspring—the larvae—that eat corn roots. But the larvae are harder to count than beetles because they are underground.

"Under standard methods, corn farmers apply soil insecticide as a preventive measure, even though it's only needed less than half of the time. By targeting the beetle parents, we attempt to keep larvae levels low for the next corn season," Chandler says.

The baits do not pose any risk to bees or other beneficial insects, such as ladybugs. And the bitter cucurbitacin doesn't appeal to any other insects, Chandler says. "The musky smell released when a cantaloupe is cut open comes primarily from cucurbitacin, which is also found in cucumbers and squash."—By **Don Comis,** ARS.

This research is part of Crop Protection and Quarantine (#304) and Integrated Agricultural Systems (#207), two ARS National Programs described on the World Wide Web at http://www.nps.ars.usda.gov.

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No Coddling for This Moth

When ARS began the Codling Moth Areawide Suppression Program in 1994, many apple and pear growers were skeptical. The aim was to reduce pesticide usage on orchards in Washington, Oregon, and California, using mating disruption, biological control, and other techniques developed over the previous 30 years.

"This program brought together, for the first time, the existing knowledge about monitoring, mating disruption, and secondary pests and showed growers that they can control pests at a reasonable cost while reducing pesticide use," says ARS entomologist Carrol O. Calkins.

Without control, codling moths could destroy 80 percent of the Northwest's apple crop and half the pear crop. More than half the nation's commercial apples come from Washington.

Normally, growers sprayed up to six times per year for codling moths and four to six more times for leafrollers, aphids, and other secondary pests. This meant using about 2 million pounds of insecticides annually. The Food Quality Protection Act restricts use on apples and pears of organophosphate pesticides, which are the most effective pesticides against codling moths.

Key to the project was grower participation. The team started with 5 sites and 68 participants encompassing about 3,000 acres. Today, more than 100,000 acres of orchards in the three states use integrated pest management—and new growers join every year. Growers have reduced their pesticide use by 80 percent.

Calkins leads research at the ARS Yakima Agricultural Research Laboratory, Wapato, Washington, and oversaw the program until it ended in 1999. A second, university-led phase with ARS participation continues to expand the project and add new techniques to the control repertoire.

SCOTT BAUER (K7618-8)

Entomologist Brad Higbee examines a Golden Delicious apple for codling moth damage.

Success so far has relied on disrupting mating with pheromones and releasing sterile male moths. The goal of both techniques is to reduce the ability of codling moths to mate and produce offspring. This reduces the population in each succeeding generation.

Reducing pesticides has also led to new information on secondary pests.

"At first, populations of leafrollers and aphids increased," says Calkins. "But without sprays, their natural enemies soon kept many of them in check." Research at the Wapato laboratory was the first to show that spiders play an important role as predators of fruit pests.

"The biggest problem now is stinkbugs," says Calkins. "Although a sex pheromone for one of these species has been identified, stinkbugs are active during the day. They use several cues, including visual cues, to find a mate, so trapping with a sex pheromone alone is seldom effective," he says.

New research may give growers more tools to control the moths and other pests: lures for female codling moths; moth parasitoids; additional predators for leafrollers, aphids, and leaf miners; and genetically engineered codling moths that lay eggs that die when temperatures fall below 65˚F.—By **Kathryn Barry Stelljes,** formerly with ARS.

This research is part of Crop Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at http://www.nps.ars.usda.gov.

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